In-situ Synchrotron X-ray Microdiffraction Study of Deformation Behavior in Copper-Polycrystals during Uniaxial Deformations

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INTRODUCTION

Recent experiments have shown that the plastic deformation and the fracture of solid have relation with the formation of dislocation cell structure and the rotation of structural elements[1]. Therefore, attention should be focused on a mesovolume of deformed material. Because The local stress and strain differ from those averaged at the macroscale, the discrete nature of the micro-deformation of the mesofragments should be accounted for the rotation of the different mesofragments being parts of subgrain, a grain, grains, etc., which plays an important role in plasticity. Moreover, In-situ study of deformation behavior in polycrystalline material during deformations at microlevel had not been performed. In the present work, we have investigated plastic deformation behavior in polycrystalline material during deformations at microlevel using the X-ray Microdiffraction technique on beamline 7.3.3. at the ALS. This technique allows the measurements of local orientation and strain in microvolume element within a grain. In addition, an accuracy of this technique is about $2x10^{-4}$ in strain and less than 0.01^{o} in orientation[2].

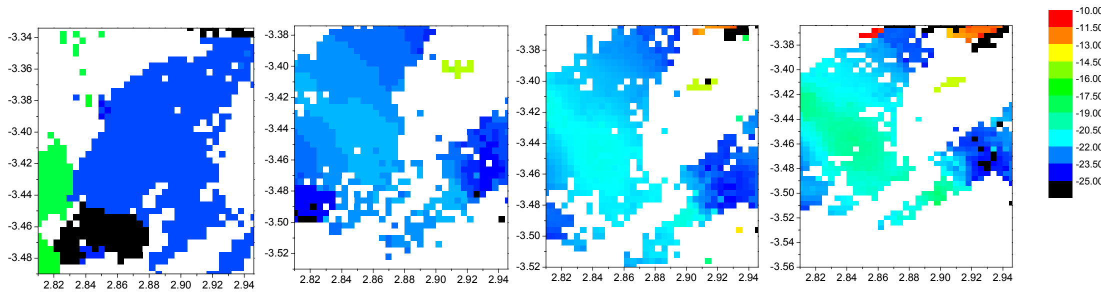
EXPERIMENT

The material used in the present study was a 99.999% pure polycrystal of copper. A tensile sample, with a gauge length of 7.5mm and a cross-section of 2x0.5 mm, was prepared by spark-erosion cutting. After mechanical polishing, the sample was annealed in a vacuum at 600□ for 30min. and chemically polished to remove damaged and oxidized surface material formed during mechanical polishing and heat treatment.

The synchrotron radiation source of beam line 7.3.3 at the Advanced Light Source (ALS) was used for the *in situ* Microdiffraction Laue experiment, described in [2,3]. In order to measure Orientation and strain/stress distributions at each strain(0, 2, 4, 6, 8, 10, 15, 20, 25, 30% strain), a large number of diffraction pattern are collected by scanning the sample and analyzed. The beam size of experiment was 1.5μm x 1.5μm and the detector was a charge-coupled device camera. The samples were elongated in steps of 0.15 mm by a tensile device mounted on the translation stage. The strain rate was $2.22x10^{-4}$.

RESULTS AND DISCUSSION

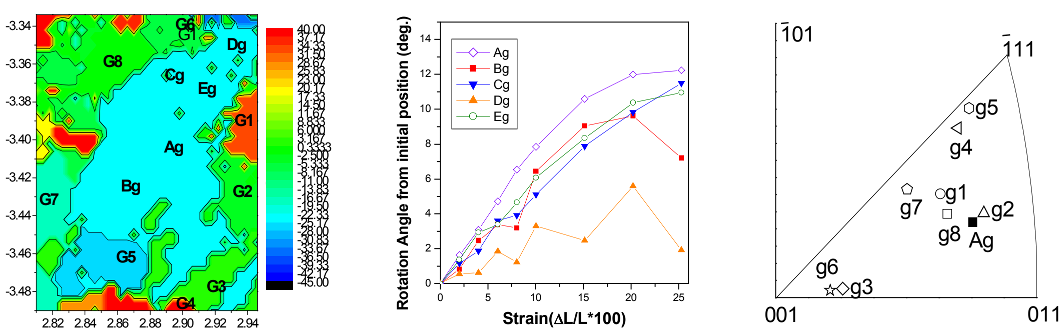
Figure 1 shows the orientation distribution of Copper sample at each deformation step(0, 2, 4, 6% strain). The tensile direction is vertical in the plots. The orientation of big center grain starts to change starting in the middle of the grain as the tension applied. In order to consider the heterogeneities of the deformation-induced microstructure within single grains, tensile axis rotation in other position within a grain is measured. We take five local positions in center grain which are Ag, Bg, Cg, Dg and Eg position, and measure the tensile axis rotation at each point. Figure 2(a) shows positions of 5 points.



(a) (b) (c) (d)

Fig.1.Grain Orientaion distribution of Copper sample at each deformation step((a)0, (b) 2, (c) 4, (d) 6% strain).

Figure 2(b)(c) shows rotation angle from initial position as a function of strain at each strain, and the orientation of neighbor grains in standard triangle, respectively. The tensile axis rotation at Ag position is larger than that at Dg position. The initial orientation of grain 2,8 near Ag position is similar to that of center grain while the angle between grain 5,6 and center grain is quite large. That is, the grain boundary in diagonal direction is small angle boundary. In the orientation map, primary slip direction ($\bar{1}01$) at sample coordination is (0.172,-0.363, 0.378) which is a diagonal direction in the plot. This phenomenon may be due to differences in the selection of simultaneously acting slip systems among neighboring volume elements of individual grains and different part of grain interior. Lattice rotation near high angle grain boundary is large while Lattice rotation near low angle grain boundary is small. This means that Grain boundary and grain orientation affect the slip behavior.



(a) (b) (c)

Fig.2. (a) shows positions of 5 points,(b)(c) shows rotation angle from initial position as a function of strain at each strain, and the orientation of neighbor grains in standard triangle, respectively.

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